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AIR POLLUTION ASSESSMENT IN THE MAIN ROADS OF SURABAYA-INDONESIA DURING POST COVID-19

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Abstract:

An increase in population in Surabaya City may have an impact on the activities of industrial, trade and service centres. One of the most important supporting facilities is the transportation sector. The use of fuel in transportation is the main cause of the impact on air quality. This study aims to evaluate the concentration of carbon monoxide on main roads in Surabaya City and to analyze the effect of vehicles on carbon monoxide on the main roads in the city of Surabaya on covid-19 transition. The research was conducted in the field by directly measuring the concentration of carbon monoxide and the number of vehicles on three main roads in Surabaya. The results of carbon monoxide measurements and the number of vehicles were analyzed using linear regression. This research reveals that, generally, the carbon monoxide concentration has exceeded the air quality standard based on Government Regulation no. 22 of 2021. This result indicates that many people have traveled for various activities in the city after the covid-19 outbreak. In addition, based on the results of the linear regression test, it is known that there is a significant effect of the number of vehicles on the carbon monoxide concentration.

Keywords: Carbon Monoxide, Covid-19, Main Roads, Transportation, Vehicles.

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INTRODUCTION

Population growth in the city of Surabaya is increasing every year. In 2000, 2.4 million people lived in Surabaya, which increased dramatically to more than three million in 2011 (Mahriyar and Rho 2014). An increase in population can have an impact on the activities of industrial, trade and service centers that will continue to grow. Urban and economic development make urban communities need social and economic support facilities. One of the most important supporting facilities is the transportation sector. The use of fuel in the transportation sector is the main cause of the impact on air quality. The process of burning fuel oil can emit pollutant compounds into the air, including dust/particulates (TSP), carbon monoxide (CO), total hydrocarbons (HC), nitrogen oxides (NO), Sulphur oxides (SO) and photochemical oxidants. The concentration of carbon monoxide (CO) pollutants in the air, 80.22 - 92.00% (eighty points twenty-two to ninety-two percent), comes from motor vehicles. Motor vehicles are a source of carbon monoxide (CO) air pollutants. A recent study in the City Centre of Brisbane, Australia, stated that both the concentration of Carbon Monoxide (CO) and Particulate Matter ($PM_{2.5}$) showed high concentrations during busy traffic hours during the day (Jayaratne et al., 2021).

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Low air quality may cause various impacts on the environment, humans, animals, plants and materials. The impact of monoxide (CO) in the air when it reacts with oxygen (O_2) will create carbon dioxide (CO_2) that can cause global warming. Air pollution has also been shown to negatively impact human health, including respiratory and heart-related diseases (Tang et al., 2018) and death (Huang et al., 2018). The presence of air pollutants, including particulates (PM_{10}), ozone (O_3), ammonia (NH_3) and nitrogen dioxide (NO_2), can cause livestock death (Egberts et al., 2019). Various experts have observed the impact of pollutants on plants to cause physiological, genetic, and metabolic changes (Singh, 2020) and morphological and anatomical impacts in some plant leaves (Al-Obaidy et al., 2019). A previous study suggested that gaseous exposure affects vegetable growth, such as lettuce (Munfarida and Sofyan 2019). Air pollution can also cause material damage, as mentioned by Nevers (2004), who describes air pollution as causing damage to building materials and statues in Europe (Nevers, 2004). Today, air pollutants remain a threat to natural and managed ecosystems (Stevens et.al., 2020).

An effort to improve environmental quality is not only the government's responsibility but also of each individual. It is related to the release of air pollutants from the vehicles used by everyone due to their activities. It is necessary to prevent environmental damage to prevent permanent natural damage. Prevention of damage is essential, one of which is through monitoring air quality due to vehicles or caused by traffic so that efforts to prevent and overcome air pollution can be carried out. In addition, during covid-19 outbreaks, Indonesia has implemented regulations on Covid-19 Prevention, that is, the Implementation of Restrictions on Community Activities. Only those people who get a permit and have met the requirements can travel within the city for work (WFO). This restriction regulation consists of levels 1 to 4. This research was conducted under regulation level 1, where at level 1, WFO (Work from Office) has been allowed up to a maximum of 75% (seventy-five percent) or a maximum of 4 (four) working days in the office in one week. Given the importance of mitigating and adapting air pollution, especially during the transition of post covid-19, it is necessary to study the effect of motorized vehicles on carbon monoxide (CO) air pollutants on main roads of Surabaya City, Indonesia. Based on this description, the researcher conducted a study entitled "Air Pollution Assessment in the Main Roads of Surabaya-Indonesia During Post Covid-19".

METHODS

The research was conducted on September 2021 during the transition of post covid-19 pandemic in the city of Surabaya, Indonesia. Measurement of carbon monoxide according to Government Regulation Number 22 of 2021 concerning Implementation of Environmental Protection and Management with sampling time carried out at one hour in the range of 10.00-14.00 West Indonesian Time at each predetermined sample point. Measurements were carried out at each sample point on a roadside basis according to the guidelines of the Indonesian national standard of 19-7119.9-2005. Measurements were carried out digitally using a CO Analyzer to measure the concentration of carbon monoxide and a counter application to measure the number of motorized vehicles. The measurement of the research sample was carried out for 4 (four) days, on Thursday to Friday as a weekday and Saturday to Sunday as a weekend. Determining the two days is done to distinguish measurements during holidays and working days. There are 3 (three) data collection stations on the main roads in Surabaya, namely Ahmad Yani Street, Darmo Street and Tunjungan Street. The results of the carbon monoxide measurements were compared with the ambient air quality standards. The indicators used to compare quality standards are Government Regulation of the Republic of Indonesia Number 22 of 2021.

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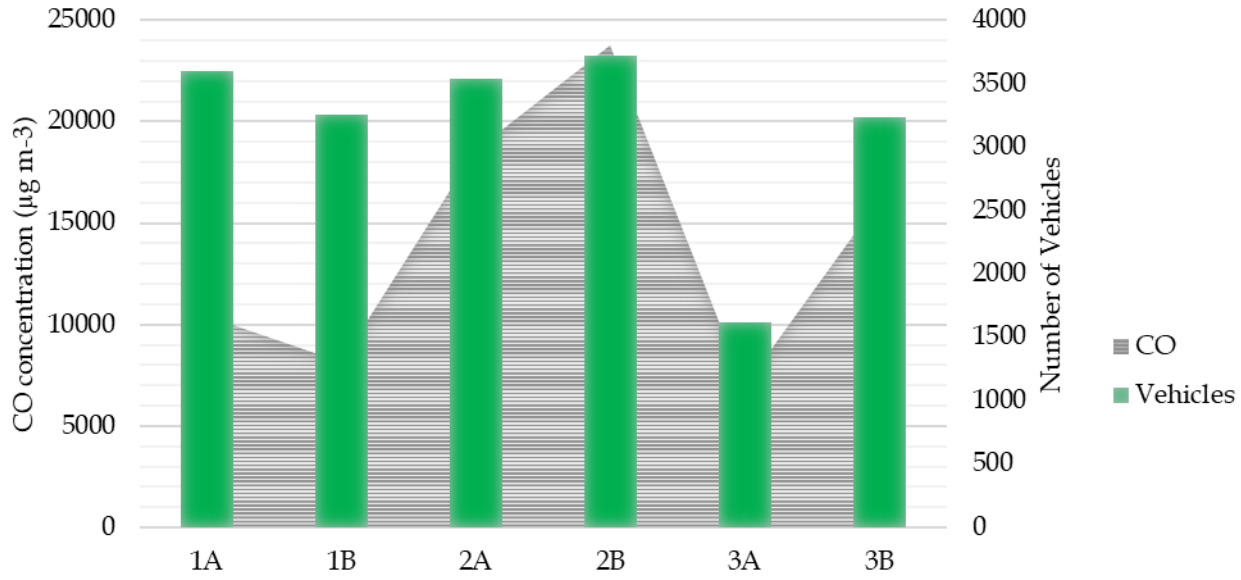
RESULT AND DISCUSSION

The research was conducted on September 2021 during the transition of post covid-19 pandemic in the city of Surabaya, Indonesia. At the time of the study, the City of Surabaya implemented Indonesia's Government Policy on Implementation of Restrictions on Community Activities (Pemberlakuan Pembatasan Kegiatan Masyarakat or PPKM) due to Covid-19 Prevention at level 1. PPKM began to be implemented throughout Java and Bali on July 3, 2021, with different level policies in each city in Indonesia. The government has started establishing an emergency PPKM starting PPKM on July 3, 2021, until the end of PPKM level 4 on August 8, 2021. In the emergency PPKM, all employees must be at home or WFH (Work from Home). In addition, at this level, the main roads of Surabaya City and the public market were closed. Continued on August 2021, the Government established the City of Surabaya PPKM at level 3, where various sectors of activity began to be opened on a limited basis.

Furthermore, from the beginning to the end of September 2021, the Government established PPKM in the City of Surabaya at levels 2 and 1. The regulation for implementing PPKM is regulated in Government Regulation No. 16 of 2021 concerning Provisions for Travel of Domestic People during the Corona Virus Disease 2019 (COVID-19). The regulation stated that at level 1, WFO (Work from Office) had been allowed up to a maximum of 75% (seventy-five percent) or a maximum of 4 (four) working days in the office in one week. Thus, in September, many people were active in the office, which correlates with the increasing number of vehicles this month, so the research on air sampling and vehicle counting was conducted on September 2021.

Based on the measurement of the carbon monoxide (CO) concentration and the number of vehicles that have been carried out during the transition of post covid-19, the results are shown in the following figure:



CO Concentration and The Number of Vehicles in the Main roads of Surabaya City on Thursday, 2021
1A: Ahmad Yani to North, 1B: Ahmad Yani to South, 2A:Darmo to North, 2B: Darmo to South, 3A: Tunjungan to North, 3B: Tunjungan to South

Source: Author, 2023

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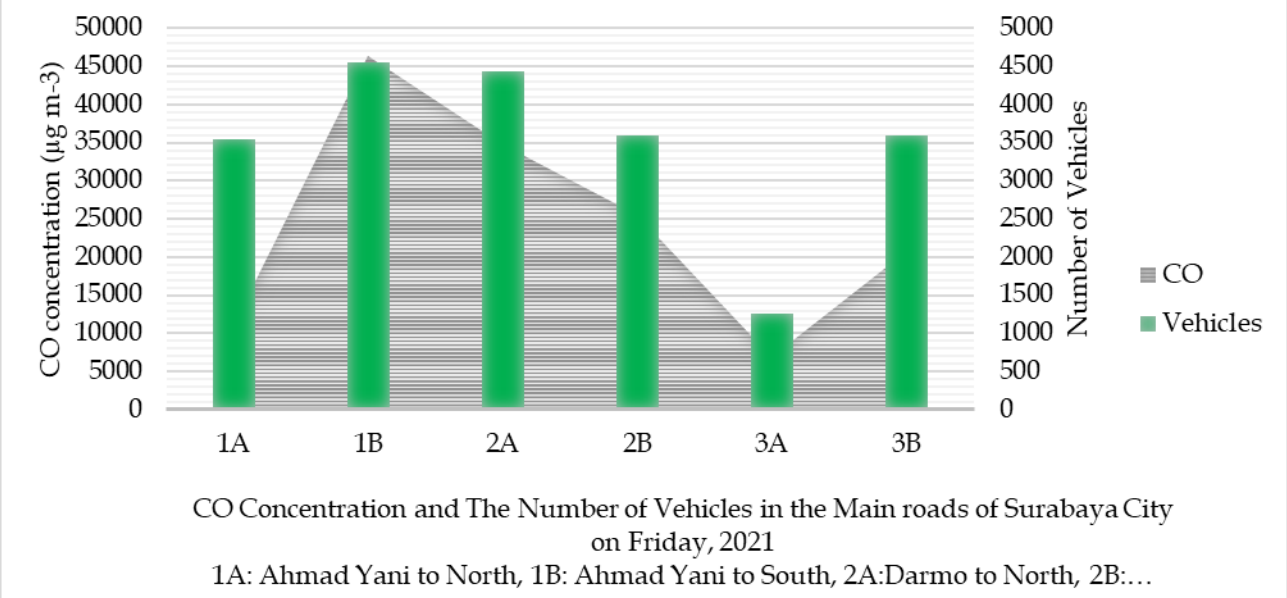
Figure 1. CO Concentration and The Number of Vehicles on the Main roads of Surabaya City on Thursday, 9 September 2021

Figure 1 shows that the highest CO concentration value on Thursday occurred at location 2-point 2B, Darmo Street, headed South. Compared with the quality standard based on Government Regulation no. 22 of 2021 (ambient air quality standard is 10,000 µg m^{-3}), the concentrations that exceeded the ambient air quality standard occurred at location 2, Darmo Street, both North and South directions, in addition, the location that has exceeded the quality standard was location 3-point 3B, Tunjungan Street at South direction. Meanwhile, the number of vehicles based on Figure 1 showed that the highest number on Thursday occurred at location 2-Point 2B Darmo Street towards the South. In contrast, the lowest number of vehicles occurred at 3-point 3A Tunjungan Street towards the North. On the other hand, the highest value of CO concentration on Friday occurred at location 1-point 1B, Ahmad Yani Street, headed South (Figure 2).



CO Concentration and The Number of Vehicles in the Main roads of Surabaya City on Friday, 2021
1A: Ahmad Yani to North, 1B: Ahmad Yani to South, 2A:Darmo to North, 2B:…

Source: Author, 2023

Figure 2. CO Concentration and The Number of Vehicles on the Main roads of Surabaya City on Friday, 10 September 2021

Compared with the quality standard based on Government Regulation no. 22 of 2021 (ambient air quality standard is 10,000 µg m^{-3}), the concentrations that have exceeded the ambient air quality standard occurred at location 1-point 1B Ahmad Yani Street headed South, Darmo Street both North and South directions, and Tunjungan Street at point 3B, at the South direction. In addition, Friday's highest number of vehicles occurred at location 1-point 1B Ahmad Yani Street, headed south. In contrast, the lowest volume of vehicles occurs at location 3-point 3A Tunjungan Street headed north.

Carbon monoxide (CO) concentration and the number of vehicles on the weekend are represented on Saturday and Sunday in the following figure.

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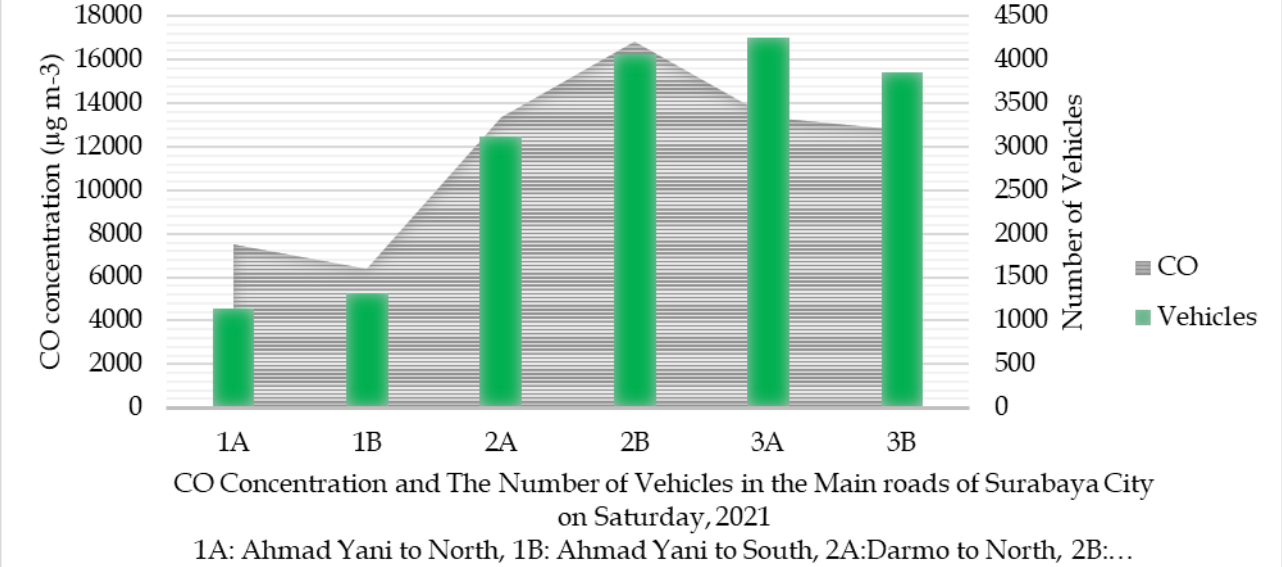
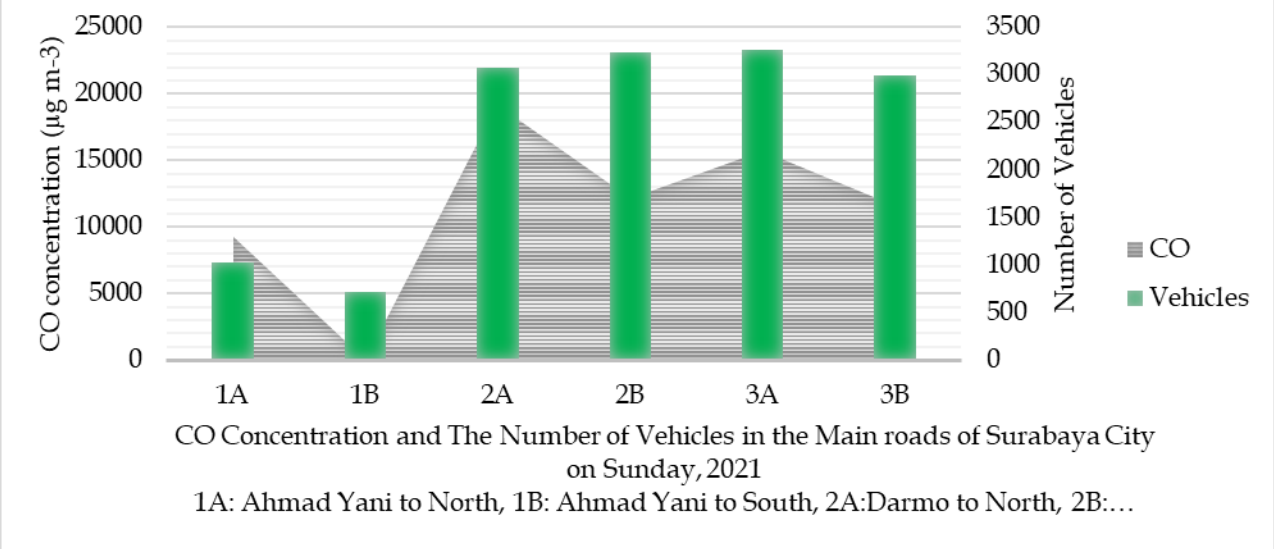


Source: Author, 2023

Figure 3. CO Concentration and The Number of Vehicles on the Main roads of Surabaya City on Saturday, 11 September 2021

The highest value of CO concentration on Saturday occurred at location 2- point 2B, Darmo Street, headed south. Comparing with the quality standard based on Government Regulation no. 22 of 2021 (ambient air quality standard is 10,000 g m^{-3}), location 2, Darmo Street and location 3, Tunjungan Street, at both sides showed that their concentrations had exceeded the ambient air quality standard. Meanwhile, the highest number of vehicles on Saturday occurred at location 3- point 3A Tunjungan Street headed north, and the lowest number of vehicles occurred at location 1- point 1A Ahmad Yani Street headed north. Carbon monoxide (CO) concentration and the number of vehicles on Sunday can be seen in the following figure.



Source: Author, 2023

Figure 4. CO Concentration and The Number of Vehicles on the Main roads of Surabaya City on Sunday, 12 September 2021

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The highest value of CO concentration on Sunday occurred at location 2-point 2A, Darmo Street, headed north. Compared with the quality standard based on Government Regulation no. 22 of 2021 (ambient air quality standard is 10,000 g m^{-3}), locations 2 and 3 on both sides showed that their concentrations had exceeded the ambient air quality standard. Meanwhile, the highest number of vehicles on Sunday occurred at location 3-point 3A Tunjungan Street, and the lowest number occurred at location 1-point 1B Ahmad Yani Street headed South.

The three main roads in Surabaya City are an important route for various activities. Ahmad Yani Street is the entrance road to the center of Surabaya City. This road has four ways and became the widest street in Surabaya. Meanwhile, Darmo Street is the famous street in the heart of Surabaya, with many parks along its route. The last street is Tunjungan Street, located in the Central Business District of Surabaya, known as the most famous street in the city with its rich historical values. These tree roads have high traffic before covid-19 outbreak in Surabaya City. For example, the city government has built a frontage to reduce the traffic on Ahmad Yani Street. Frontage is a two-way primary arterial road (with separate directions) as a link between Surabaya, Sidoarjo and Mojokerto (Pramono, 2019). Based on our research, we found that the three main roads in Surabaya City have shown a high number of vehicles which correlates with carbon monoxide concentration.

According to Pratiwi (2020), the number of vehicles strongly influences exposure to carbon monoxide pollutants. The greater the number of vehicles, the higher the concentration of carbon monoxide on the main roads. The potential for carbon monoxide will be more significant if there is a high intensity of vehicles on narrow roads (Pratiwi and Zaenab 2020). Another researcher represented that vehicles are the primary pollutant contributor to carbon monoxide air pollution parameters (Pratama et al., 2022). Moreover, our finding has been proved by statistical analysis. The result of statistical analysis in this study showed that there was a significant effect of the number of vehicles on the concentration of carbon monoxide (CO) (significance p-value of < 0.05) (Table 1).

Table 1. Results of Statistical Analysis on the Number of Vehicles and Carbon Monoxide.

Model		Coefficient			t	Sig.
		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta		
1	(Constant)	-2,838.002	4,166.279		-.681	.503
	The number of vehicles	6,050	1,299	.705	4.658	.000

a. Dependent Variable: CO concentration.

Source: Data Processed 2021

Other results we have found are that some locations with a high concentration of carbon monoxide have exceeded the National Standard. The concentration of carbon monoxide in some locations that exceeded the standard showed that there was traffic on the street due to people activity around the street for shopping or working. This key road also has numerous traffic lights, contributing to increased pollution. High-intensity cars will generate incomplete combustion of the engine that reacts more quickly when they stop with the engine running, such as in a traffic jam, increasing exposure to the intensity of carbon monoxide pollution (Kurniawati et al., 2017).

This research has been conducted during the transition of post covid-19 outbreak. Although the City of Surabaya is in a PPKM stage of level 1, this research proves that many people worked and have an impact on the high level of CO pollutants exposure in the air. This finding may inform

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the Local Government that there will be a significant increase in transportation activity after the covid-19 outbreak in Surabaya, so the local government should prepare to monitor the air pollution ahead. In addition, mitigation and adaptation should be prepared to minimize exposure to CO pollutants. An example of air pollution mitigation is maintaining the green open space in Surabaya City. Many researchers have found that green open space in cities is essential in reducing air pollution. Junior et al. (2022) suggest that urban green areas can reduce particulate levels compared to places with less vegetation cover, providing better air quality. The mechanism for reducing such pollutants is particle deposition, dispersion, and modification (Diener and Mudu 2021). Other researchers stated that green space has the potential to create wins for environmental sustainability, health, and health equity (Kruize et al., 2019).

CONCLUSION

This research has been conducted during the transition of post covid-19 outbreak. Based on Government Regulation No. 22 of 2021, there was a location that exceeded the quality standard for each day that was; Darmo Street and Tunjungan Street headed south on Thursday, Ahmad Yani Street headed south, Darmo Street both north and south directions and Tunjungan Street in South direction on Friday, Darmo Street and Tunjungan Street at both sides on Saturday and Sunday. This result indicates that many people have traveled for various activities in the city after the covid-19 outbreak. In addition, based on the results of the statistical analysis, it is known that there is a significant effect of the number of vehicles on the CO concentration (significance p-value < 0.05). Mitigation and adaptation should be prepared to minimize exposure to CO pollutants.

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